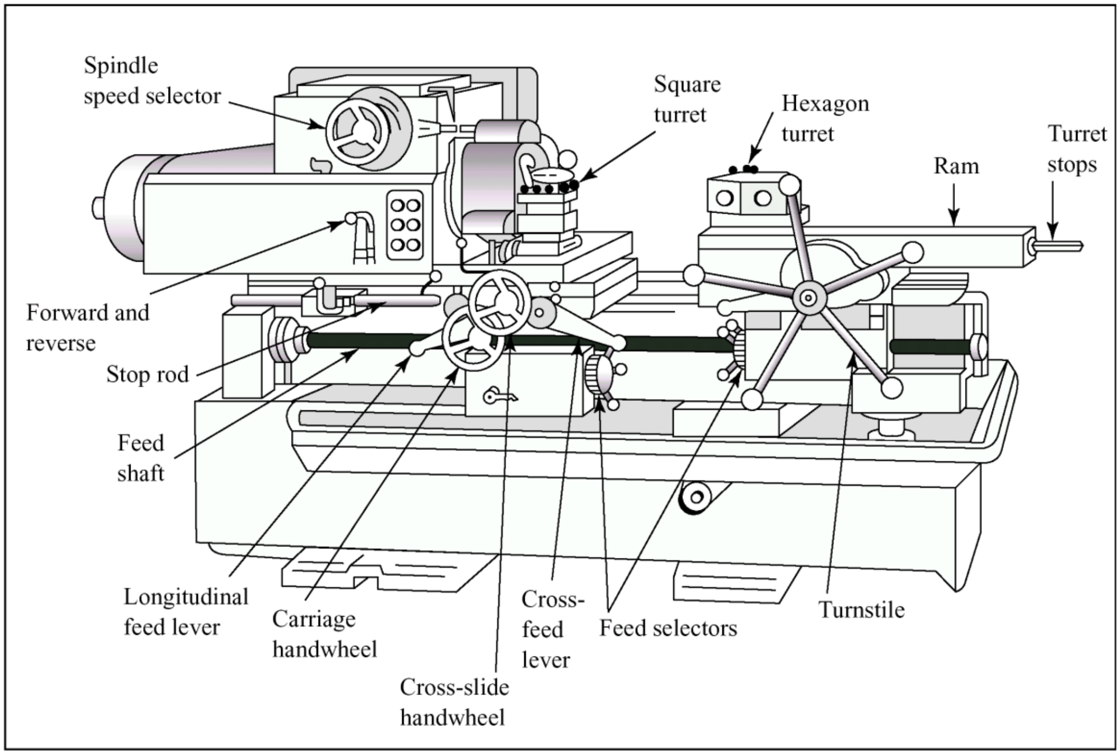
Faculty of Engineering
Design and Production Department
3rd year Mechanical

Capstan and Turret Lathes



1- مصطفى ممدوح عبد الله عمر	4
2- محمد وجيه نعيم محمد	4
3- محمد عادل السيد علي	3
4- أحمد إبراهيم أحمد شحاته	1
5- أحمد جمال عبد الرازق عطيه	1
6- محمد أحمد زغلول محمد	3
7- محمد أحمد سيد محمود	3
8- محمد أحمد محمد أحمد الجلداوي	3
9- كريم مجدي سعد حسن	3

إلى: د.وائل عقل

التاريخ: 11/ 4/ 2011

Table of contents

I- Introduction: 2
- **Automation:** 2
- **Useful use:** 2

II- Construction and mechanisms: 3
Capstan lathe 3
III- Operations 7
IV- Mechanisms: 8
1- Bar feed mechanism: 8
2- Indexing mechanism: 9
V- Different types of tool holders used in turret lathes: 10
VI- Workpiece fixations: 12
A- Three Jaw "self-centering" chuck: 12
B- Four Jaw chuck: 13
C- Multi-jaw chuck: 14
D- Magnetic chuck: 14
E- Collet chuck: 14
VII- Similarities and differences 20
The common between the capstan and turret 20
Differences between capstan and turret lathes: 20
Differences between conventional and semi-automatic lathes: 21
VIII- References: 24

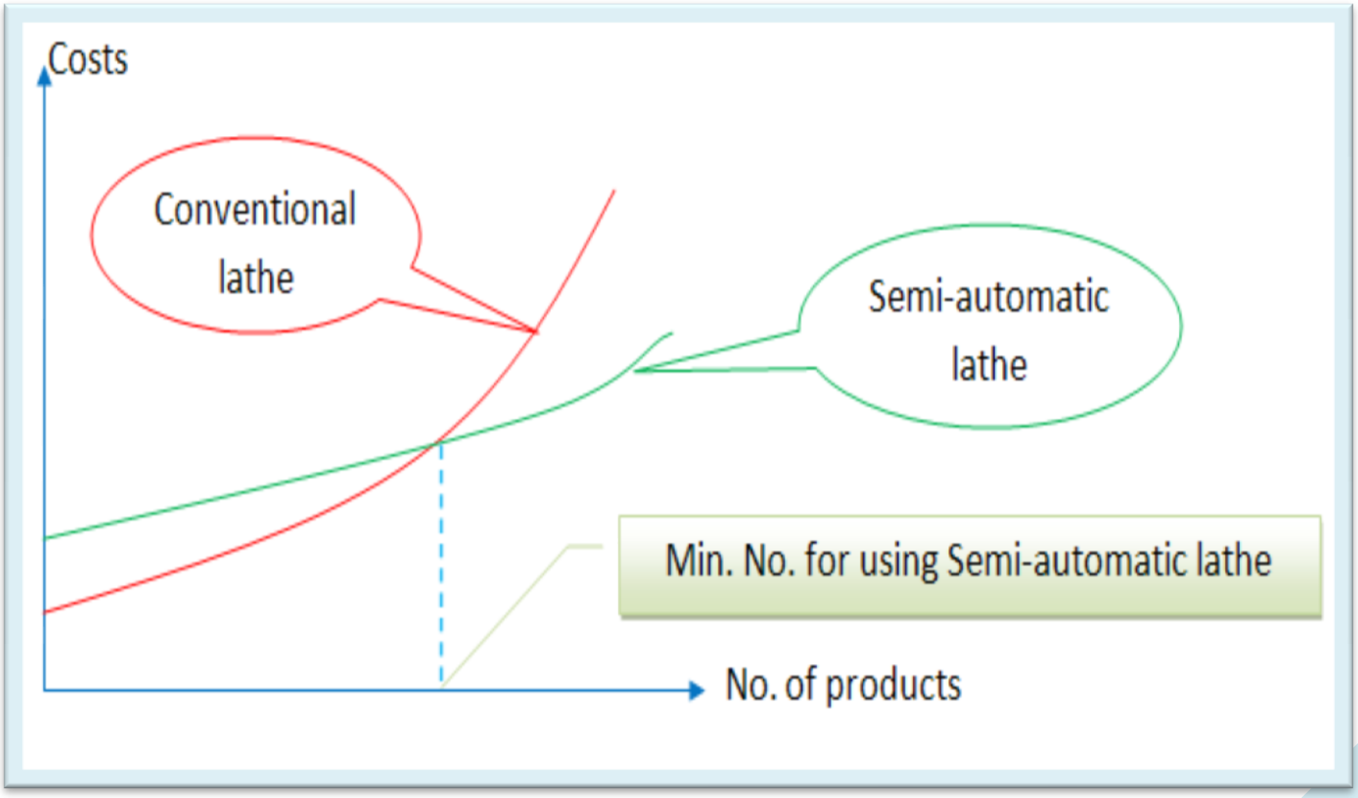
I- Introduction:

- ***Automation:***

  - Automation main target is to increase productivity economically by decreasing the time handling, mounting, raw material feeding, tool changing, cutting conditions changing, measuring…etc. using non-manual equipment, mechanically, hydraulically, electronically, combinations…etc.
  - Machines may be classified according to automation into:
    1- Non-automatic: Most operations are performedon the m/c manually.
    2- Semi-automatic: Most operations are performed on the m/c automatically as: capstan, turret, multi-spindle turret or copying (hydraulic) lathes.
    3- Automatic: All the operations are performed on the m/c automatically starting from certain stage as cutting off, single spindle, multi-spindle or Swiss-type lathes.

- ***Useful use:***

  - Semi-automatic machines are useful economically for patch or small lot production.

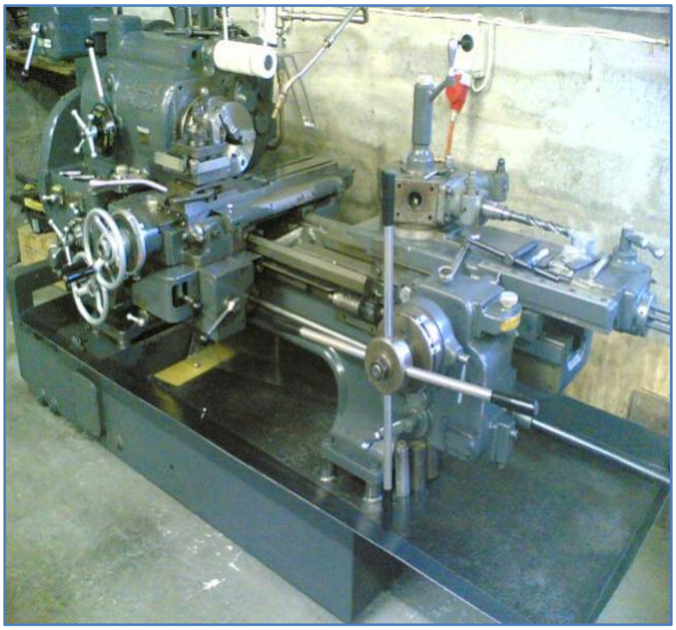


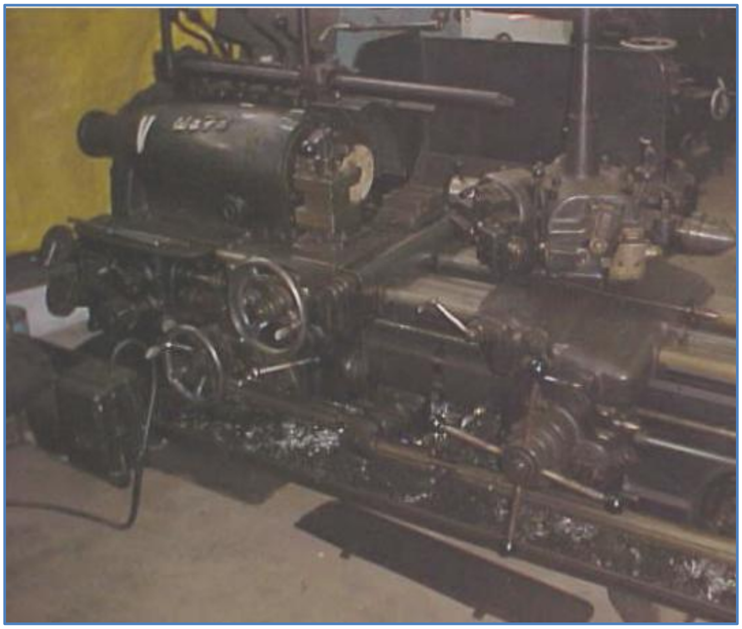
II- Construction and mechanisms:

Capstan lathe

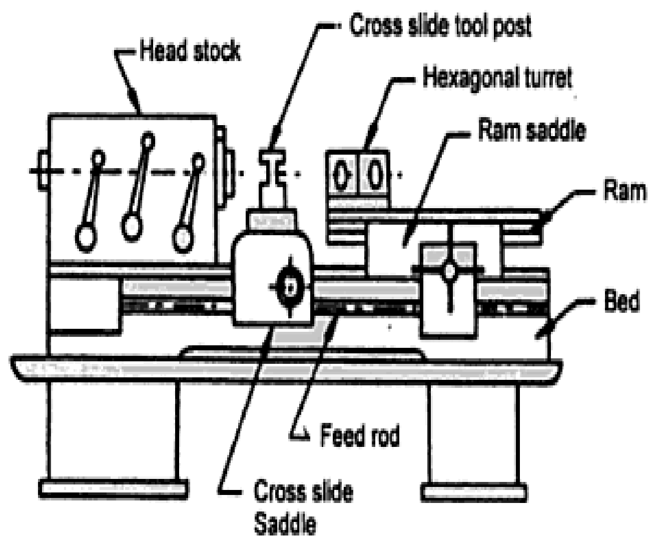
Turret lathe

- **Pictorial pictures**

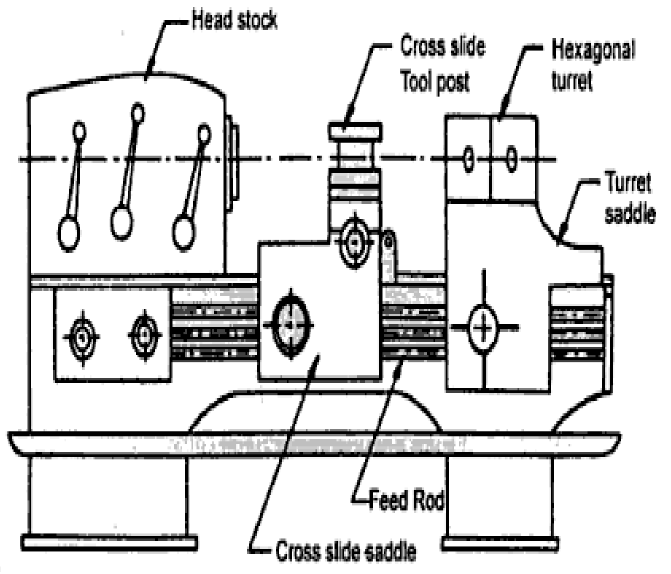




- **Outlines views**



Capstan Lathe



Turret Lathe

Main parts

- The turret has essentially the same parts as the engine lathe except the turret and the complex mechanisms for feeding and indexing.

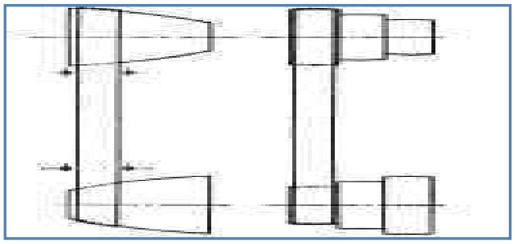
1- Bed:

The bed is a long box like casting provided with accurate guide ways (flat and v) upon whichare mounted the carriage and turret or turret saddle (For capstan). The bed is designed to ensure strength,rigidity and permanency of alignment under heavy-duty services. Like engine lathe, precision surface finishing methods must be applied to keep it resistant to wear duringservice period.

2- Headstock:

The headstock is a large casting located at the left hand end of the bed. The headstock of capstan and turret lathe may be of the following types:

A- Step cone pulley driven headstock:
For small lathes of small capacity in which 3 or 4 low speeds are allowed only using same no. of pulleys and speed is reversed using foot pedal.



B- Direct electric motor driven headstock:
Spindle (which is the same as the motor shaft is hollowed to allow feed of long workpieces through it) is driven by variable speed motor in which 3 or 4 high speeds are allowed.

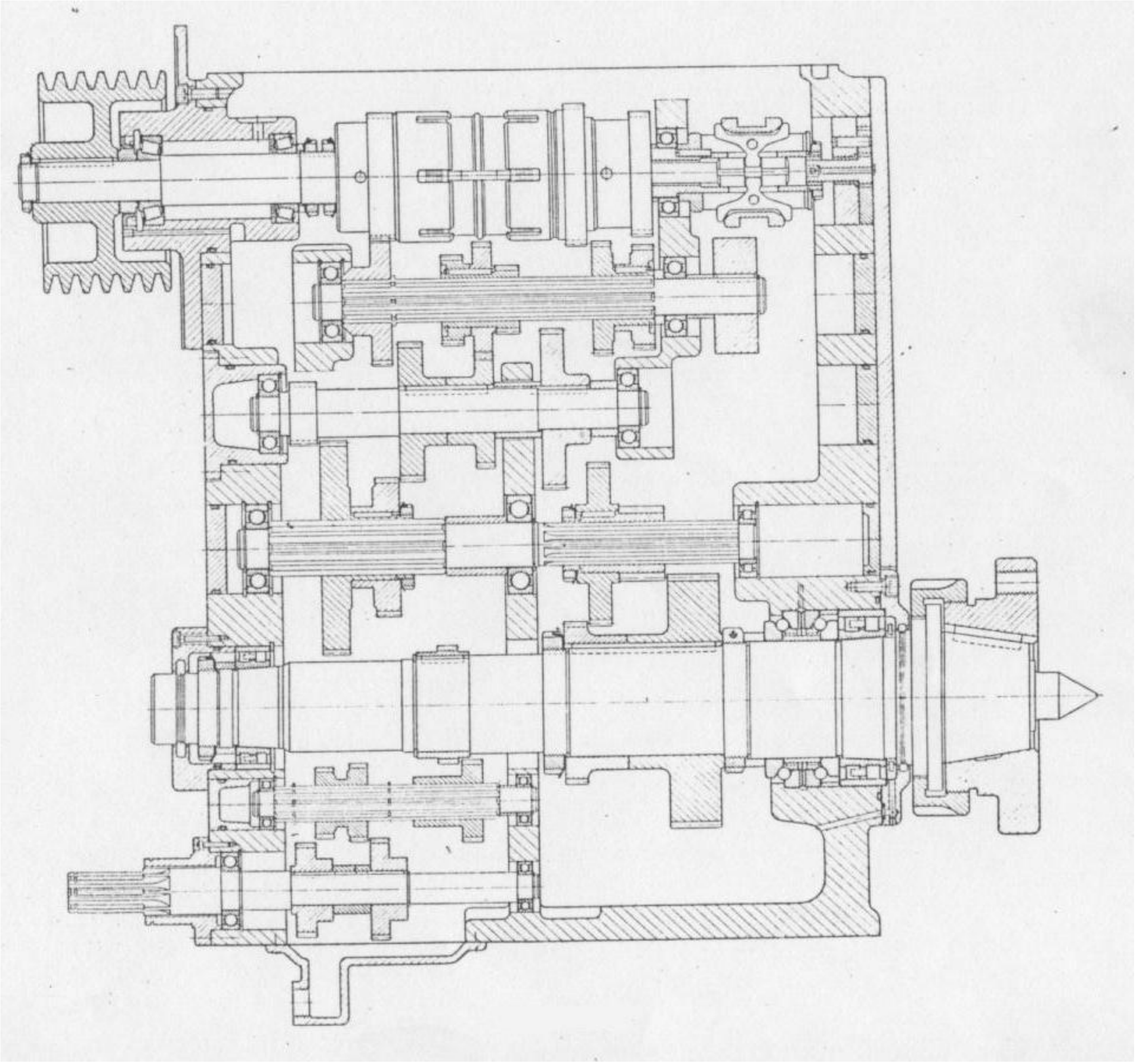
C- All geared headstock:
Sliding gears mechanisms are present to allow several speeds for the spindle from constant speed motor.

D- Pre-optive or pre selective headstock:
It is all geared headstock but has advantage of rapid start and stop of spindle to change speed without stopping the machine.

Spindle:

- Lathe spindles are often hollow and have interior, exterior threads and an interior taper on the inboard with the help, of which accessories, which hold the work piece, may be mounted to the spindle. and to allow pass of long workpieces.

- They impart motion to the work piece.
- The lathe spindles feature rigid precision bearings near the spindle nose to enhance true running.
- The spindles determine machining accuracy.
- The Lathe spindle is carefully balanced.

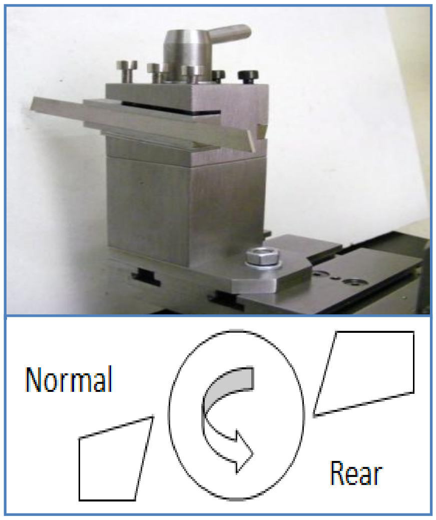


Types of spindle bearings

1) *Angular contact ball bearings*
2) *Roller bearings*
3) *Tapered roller bearings*

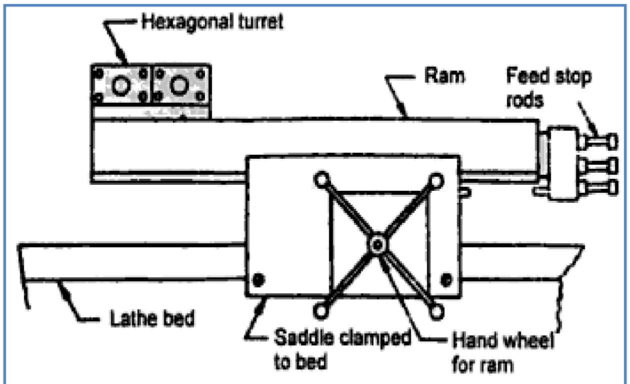
3- *Cross-slide:*

- It is provided over the bed of the lathe between the headstock and the saddle.
- It has 2 tool posts one at the front of machine, which can provide 4 tools and it can move parallel and normal to axis of machine and the other is the rear tool post which carries a parting off tool which is fitted upside down because the surface of the workpiece moves upward in the rear end opposite to normal tool post.



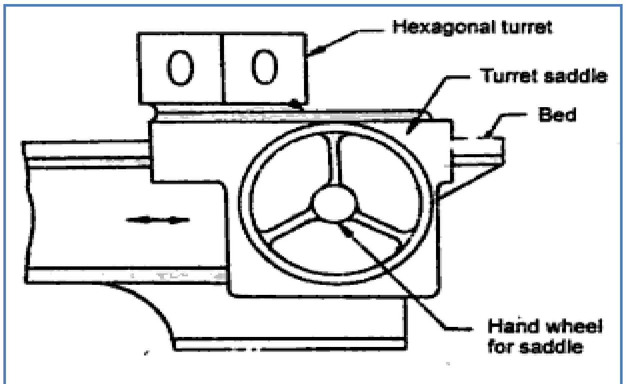
4- *Turret and saddle:*

- Turret is a block which can rotate about an axial and holds several tools, generally 6 depending on shape of turret may be square, hexagon or octagon in which by indexing of turret (rotation of it by certain angle depending on no. of tools).
- Each face has a threaded hole to receive the clamping tool holders to fix shank of tool.



Ram of Capstan Lathe

- The turret head is mounted on the ram and the ram is mounted on the saddle on the bed.

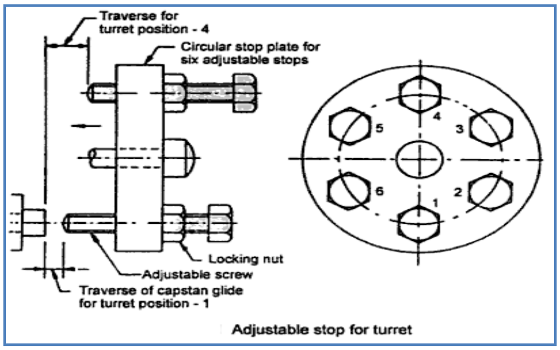


Saddle of Turret Lathe

- The turret is directly mounted on the top of the saddle and any movement of the turret is effected by the movement of the saddle.

- A star wheel is fitted at the front of the machine to move the turret to somewhere and this movement is controlled using a pre-set stop.

- By moving the turret to the initial position, it indexes by 1/n revolution, so another tool comes to the workpiece using Geneva mechanism.
- There are 6 adjustable stops for each face of turret to control the length of stroke for each tool.


Traverse for turret position - 4
Circular stop plate for six adjustable stops
5
4
3
6
2
1
Locking nut
Adjustable screw
Traverse of capstan glide for turret position - 1

Adjustable stop for turret

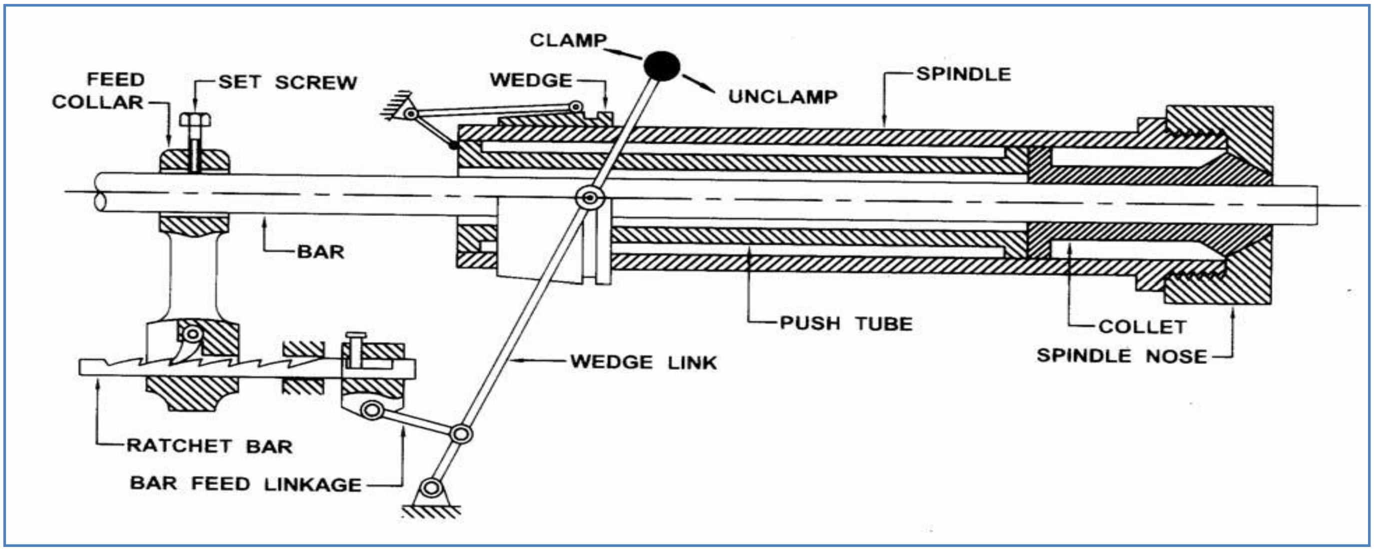
- Thecentre line of the each hole is perfectly aligned with the axis of the lathe when alignedwith the headstock spindle.

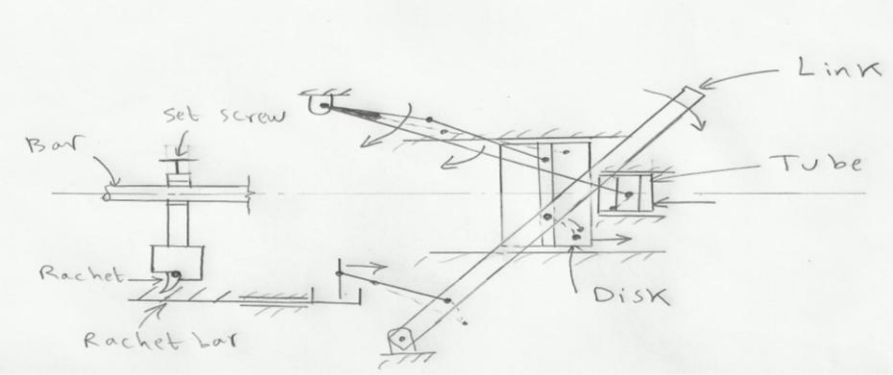
III- Operations

- The workpiece is held in collet or chuck. In turret lathes, large workpieces are held by means of jaw chucks. These chucks may be hydraulically or pneumatically operated.In a capstan lathe, bar stock is held in collet chucks.
- A bar feeding mechanism is used for automatic feeding of bar stock.
- At least eleven tools can be set at a time in turret and capstan lathes. Six tools are held on the turret faces, four tools in front square tool post and one paring off tool at the rear tool post.
- While machining, the turret head moves forward towards the job. After each operation, the turret head goes back. The turret head is indexed automatically. The next tool comes into machining position. The indexing is done by an indexing mechanism.
- The longitudinal movement of the turret corresponding to each of the turret position can be controlled independently.
- By holding different tools in the turret faces, the operations like drilling, boring, reaming, counter boring, turning and threading can be done on the component.
- Four tools held on the front tool post are used for different operations like necking, chamfering, form turning and knurling.
- The parting off tool in the rear tool post is used for cutting off the workpiece. The crosswise movement of the rear and front tool posts are controlled by pre-stops.

IV- Mechanisms:

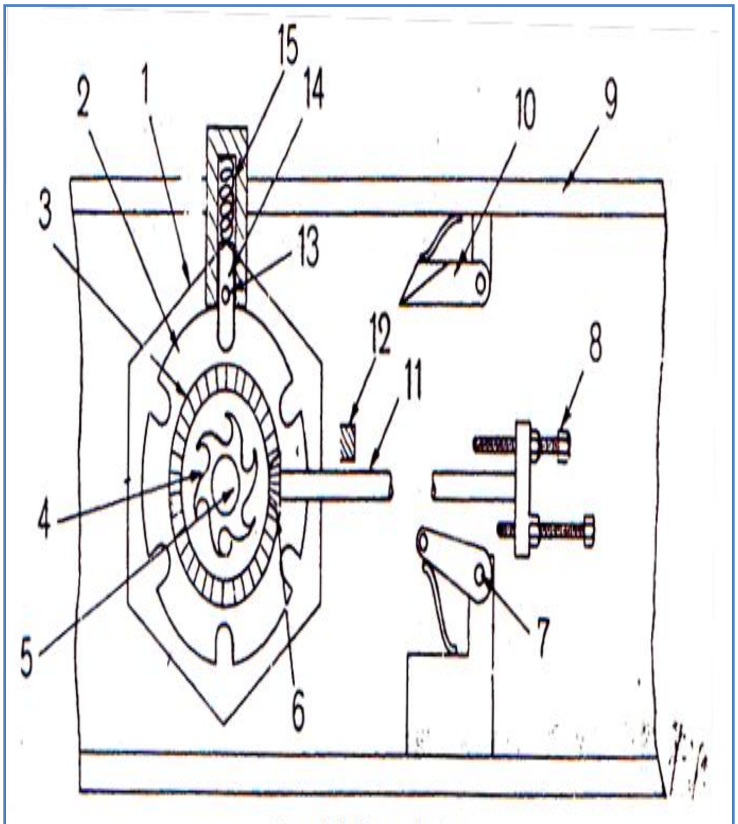
1- *Bar feed mechanism:*



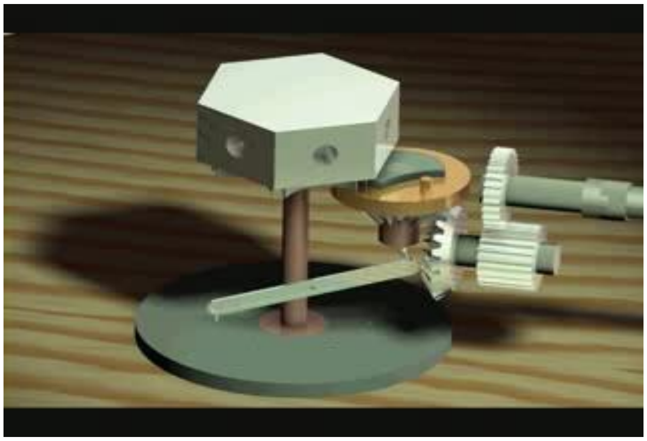


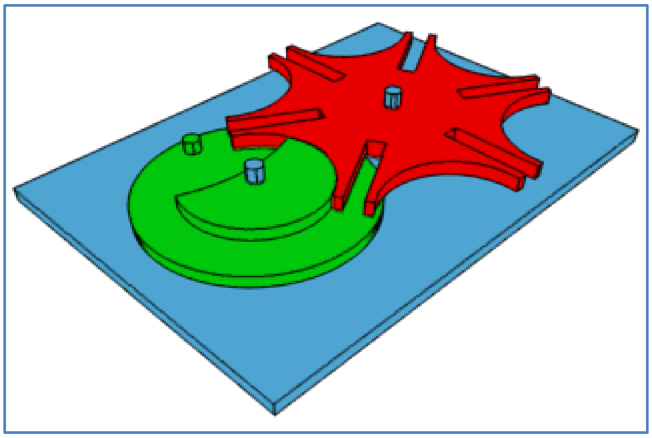
- By rotating the link clockwise, the pin moves downwards moving the disk right, so the welded link moves anticlockwise so push tube moves left causing the collet to unclamp the bar.
- By rotating the link clockwise, the stopper moves towards right causing ratchet bar to move towards right so bar is fed towards the lathe.
- Synchronization occurs between motion of ratchet bar and bar mounting by setscrew.

2- *Indexing mechanism:*



Turret indexing mechanism



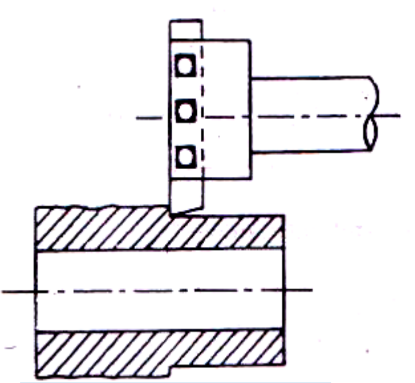


1. Hexagonal turret	2. Index plate	3. Bevel gear	4. Indexing ratchet
5. Turret spindle	6. Bevel pinion	7. Indexing pawl	8. Screw stop rods
9. Lathe bed	10.Plunger actuation cam	11.Pinion shaft	12. Stop
13. Plunger pin	14. Plunger	15. Plunger spring	

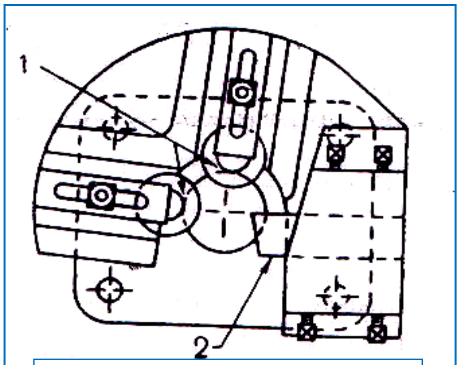
- The turret 1 is mounted on the spindle 5, which rests on bearing on the turret saddle.
- The index plate 2, the bevel gear 3 and the indexing ratchet 4 are keyed to the spindle 5.
- The plunger 14 fitted within the housing and mounted on the saddle locks the index plate by spring pressure 15 and prevents any rotary movement of the turret as the tool feeds into the work.
- A pin 13 fitted on the plunger 14 projects out of the housing.
- An actuating cam 10 and indexing pawl 7 are attached to the lathe bed 9 at the desired position.
- Both the cam and the pawl are spring loaded.
- As the turret reaches the backward position , the actuating cam 10 lifts the plunger 14 out of the groove in the index plate due to the riding of the pin 13 on the beveled surface of the cam 10 and thus unlocks the index plate 2.

- The spring-loaded pawl 7, which by this time engages with a groove on the ratchet plate 4, causes the turret to rotate as the turret head moves backward.
- When the index plate or the turret rotates through one sixth of revolution, the pin 13 and plunger 14 drops out of cam 10 and the plunger locks the index plate at the next groove.
- The turret is thus index by one sixth of revolution and again locked into the new position automatically.
- The turret holding the next tool is now fed forward and the pawl is released from the ratchet plate by the spring pressure.
- The synchronized movement of the stop rods with the indexing of the turret can also be understood from the figure above.
- The bevel pinion 6 meshes with bevel gear 3 mounted on the turret spindle.
- The extension of the pinion shaft carries a plate holding six adjustable stops rods 8.
- As the turret rotates through one sixth of revolution the bevel gear 3 caused the plate to rotate.
- The ratio of the teeth between the pinion and gear are so chosen that when the tool mounted on the face of the turret is indexed to bring it to the cutting position, the particular stop rod for controlling the longitudinal travel of the tool is aligned with stop 12.
- The setting of the stop rods 8 for limiting the feed of each operation may be adjusted by unscrewing the lock nuts and rotating the stop rods on the plate.
- Thus, six stop rods may be adjusted for controlling the longitudinal travel of the tools mounted on the six faces of the turret.

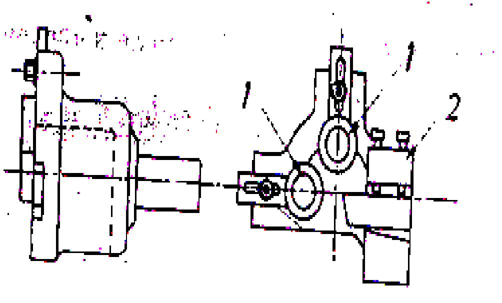
V- Different types of tool holders used in turret lathes:



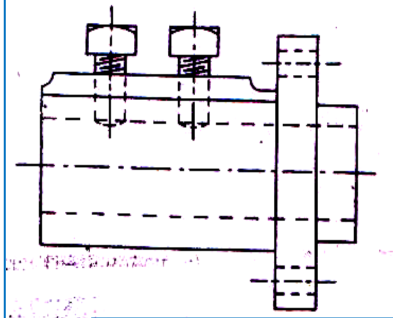
Straight cutter holder



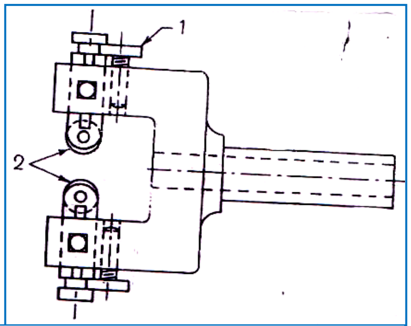
Roller steady box tool holder
1. Roller 2. Tool



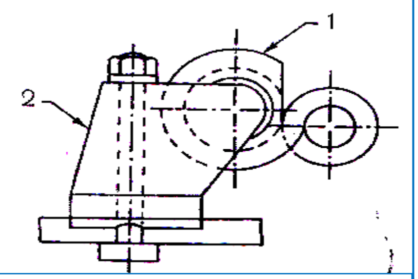
Bar ending tool holder
1. Roller 2. Tool holder



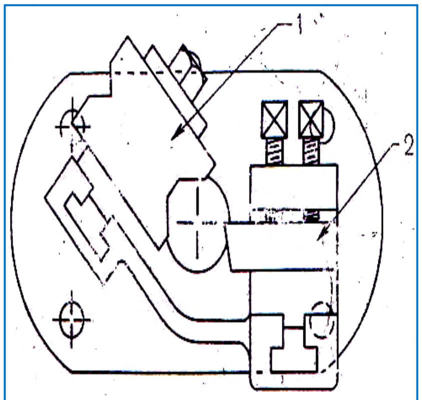
Flange tool holder



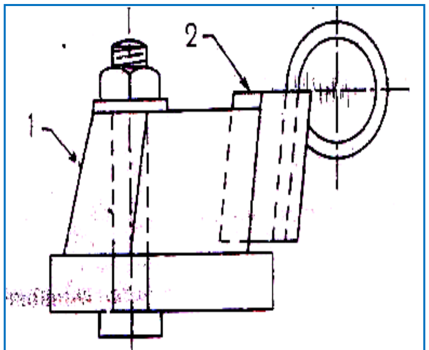
Knurling tool holder
1. Adjustable screw 2.Knurls



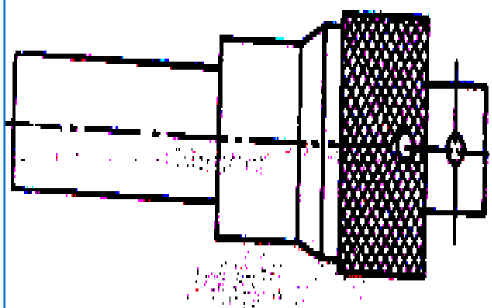
Circular form cutter holder
1. Circular form cutter
2. Holder



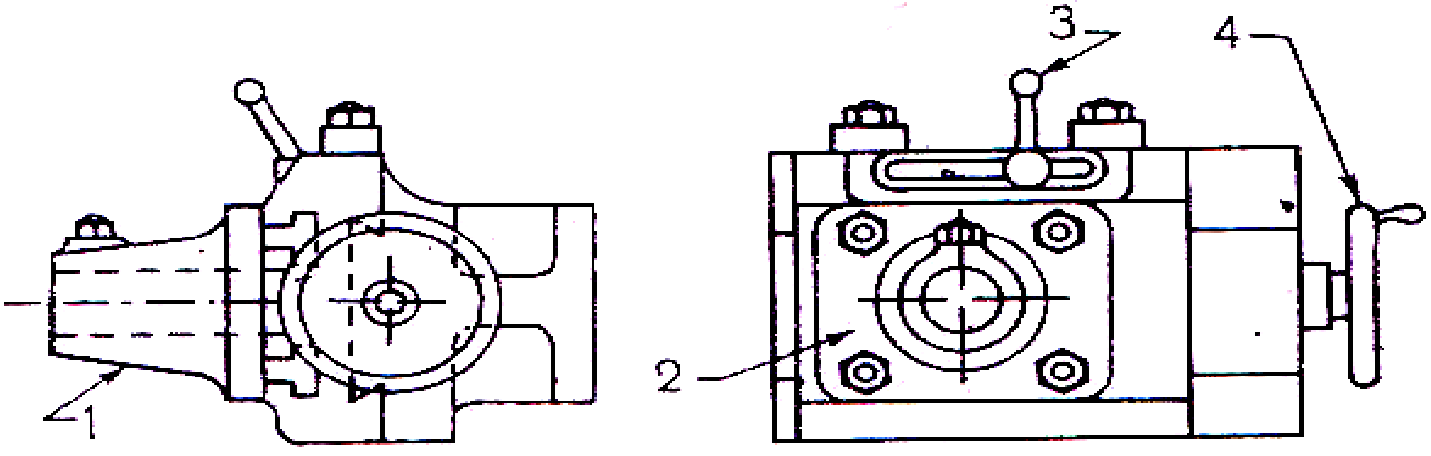
V-steady box tool holder
1. V-steady 2. Tool



Straight form cutter tool
1. Holder 2.Straight form cutter



Solid tap holder



Recessing tool holder
1. Tool holder 2. Adjustable slide 3. Adjustable slide clamp 4. Adjustable slide hand wheel

VI- Workpiece fixations:

The standard practice of holding work between two centers in an engine lathe finds no place in a capstan or turret lathe as there is dead center to support the work at the other end. Work is, therefore supported at the spindle end by the help of chucks and fixtures. The usual methods of holding work in a capstan or turret lathe are

1- Chucks

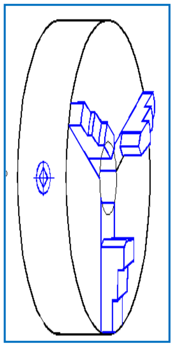
- A chuck is one of the most important devices for holding and rotating workpieces in a lathe.
- A chuck is attached to the lathe spindle by means of bolts with the back plate or screwed on the spindle nose.

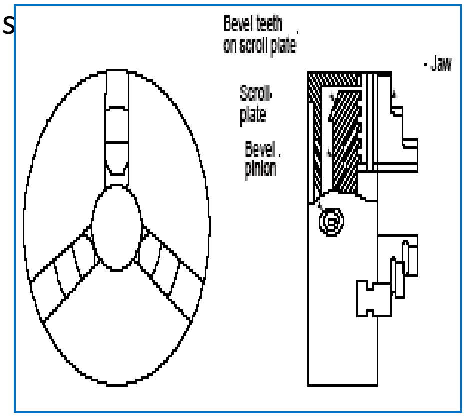
A- Three Jaw "self-centering" chuck:

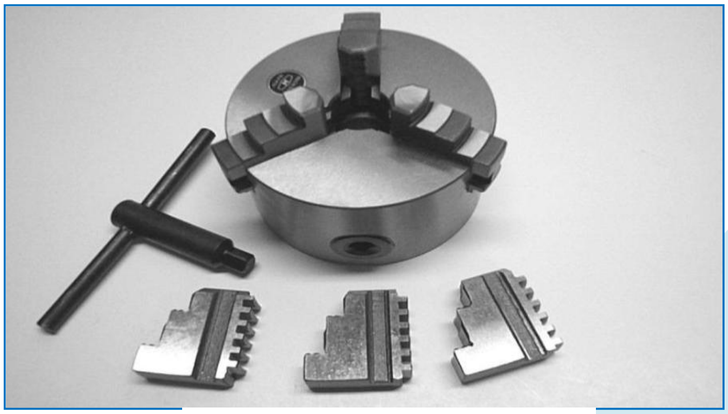
- A three-jaw chuck is used for gripping cylindrical workpieces.
- The jaws have a series of teeth that mesh with spiral grooves on a circular plate within the chuck. This plate can be rotated by the key inserted in the square socket, resulting in simultaneous radial motion of the jaws. Since the jaws maintain an equal distance from the chuck axis, cylindrical workpieces are automatically centered when gripped, Even though piece it is always a good idea to check to see is the part is running true after it has been installed.

Use:

- For a workpiece of short length and large diameter, which cannot be conveniently mounted between centers, are held quickly and rigidly in a chuck.
- For facing/center drilling
- To grip circular or hexagonal cross sections when very fast, reasonably accurate centering is





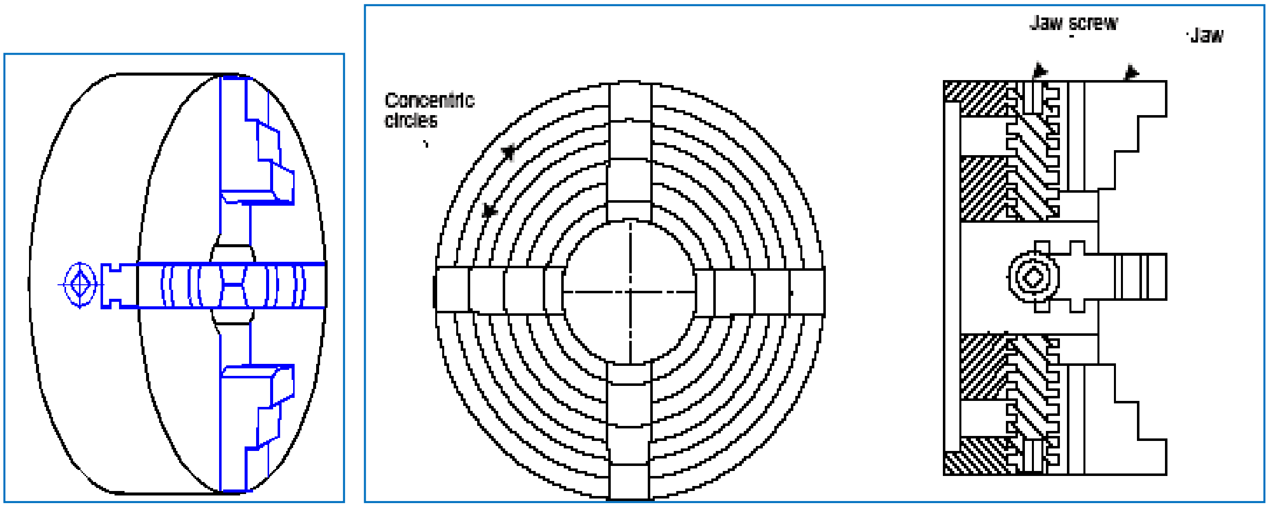


B- *Four Jaw chuck:*

- A four-jaw chuck is similar to a three-jaw chuck, but with four jaws, usually have individual adjustments for each jaw by means of adjusting screws, The non-self-centering action of the independent jaws makes centering highly controllable (for an experienced user)

USE:

- When the surface of the workpiece is to be turned is not concentric with the diameter used to mount the part.
- Gripping non-circular cross sections
- Gripping circular cross sections with extreme precision



Schematic diagram for the four-jaw chuck

C- Multi-jaw chuck:

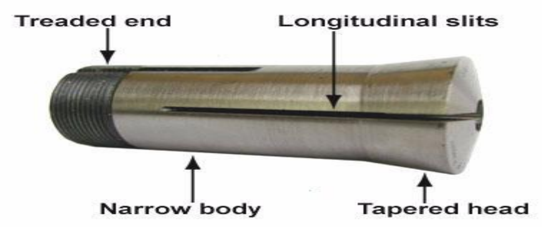
- For special purposes as holding of fragile materials
- Chucks are available with six or eight jaws.
- These are invariably of the self-centering design, and are built to very high standards of accuracy.
- Two jaw chucks are available and can be used with soft jaws (typically an aluminum alloy) that can be machined to conform to a particular workpiece.

D-Magnetic chuck:

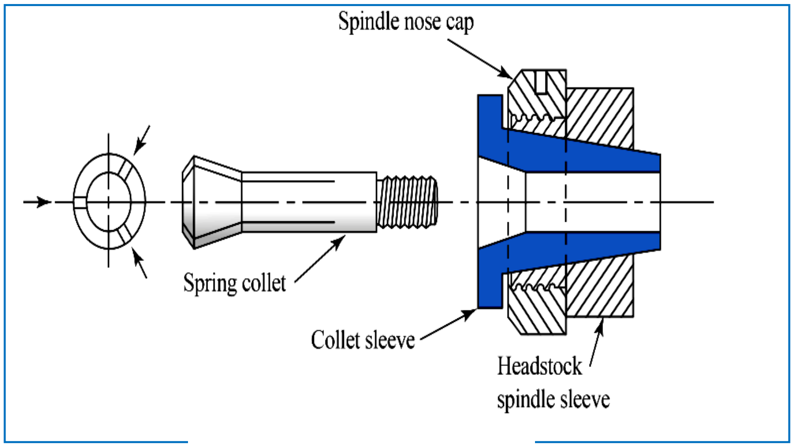
The workpieces are held in this chuck by means of powerful electro- magnets, Magnetic chuck can be used for thin jobs.

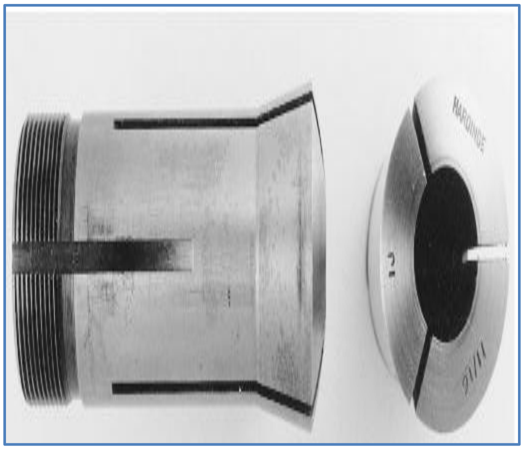
E- Collet chuck:

- The collet chucks are used for gripping bars introduced through the head stick spindle of a capstan or turret lathe and is one of the most common method of holding work.
- Different sizes of spring collets having square, hexagonal, round or any other shaped bore are fitted in the chuck body for holding different sizes of bar having different sections.
- Collets are relatively thin tubular steel bushings that are split into three longitudinal segments over about two thirds of their length. The smooth internal surface of the split end is shaped to fit the piece of workpiece that is to be held. The external surface at the split end is a taper that fits within an



internal taper of a collet sleeve placed in the spindle hole. When the collet is pulled inward into the spindle, by means of the draw bar that engages threads on the inner end of the collet, the action of the two mating tapers squeezes the collet segments together, causing them to grip the workpiece.





Types

1. **Push out type:**

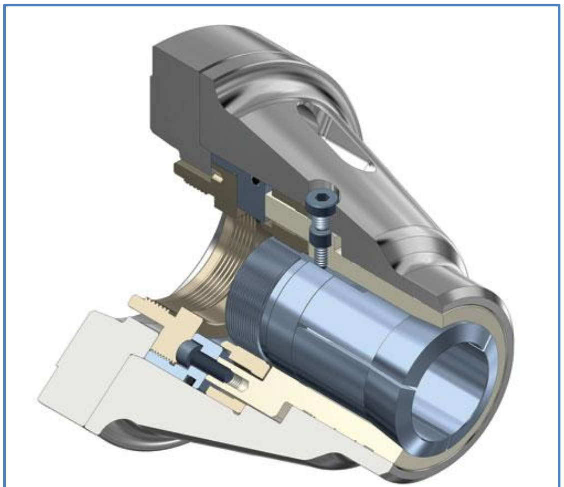
To grip the work, the tapped portion of the spring collet is pushed in to themating taper of the chuck. There is a tendency of the bar to be pushed slightly outwards when the collet is pushed in to the chuck body for gripping. If the bar is fed against astop bar fitted on the turret head, this slight outward movement of the bar ensuresaccurate setting of the length for machining.

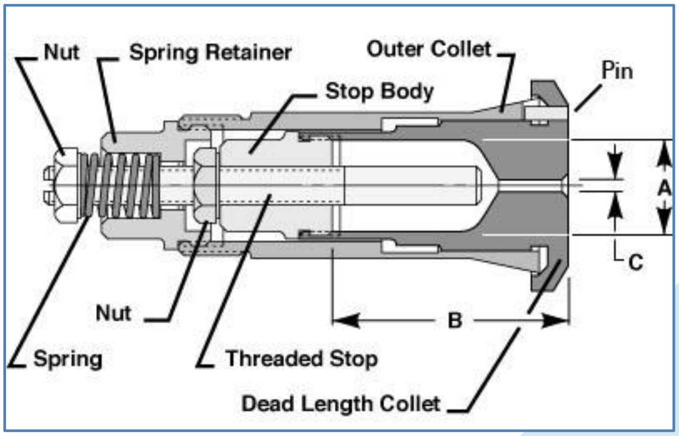
2. **Draw in type**

To grip the work, the tapered portion of the spring collet is pulled back in tothe mating taper of the chuck, which causes the split end of the collet to close in and gripthe bar. The machining length of the bar in this type of chuck cannot be accurately setas the collet while closing will draw the bar slightly outward towards the spindle.

3. **Dead length type**

For accurate positioning of the bar, both the push out and draw in typecollet present some error due to the movement of the bar along with the collet whilegripping. This difficulty is removed by using a stationary collet on the bar. A slidingsleeve closes up on the tapered collet, which is prevented from any end movement bythe shoulder stop.





Uses

- Collets are used when smooth bar, or workpieces that have been machined to a given diameter, must be held more accurately than normally can be achieved in a regular three or four jaw chuck.
- Collet chuck is used to hold small workpieces.

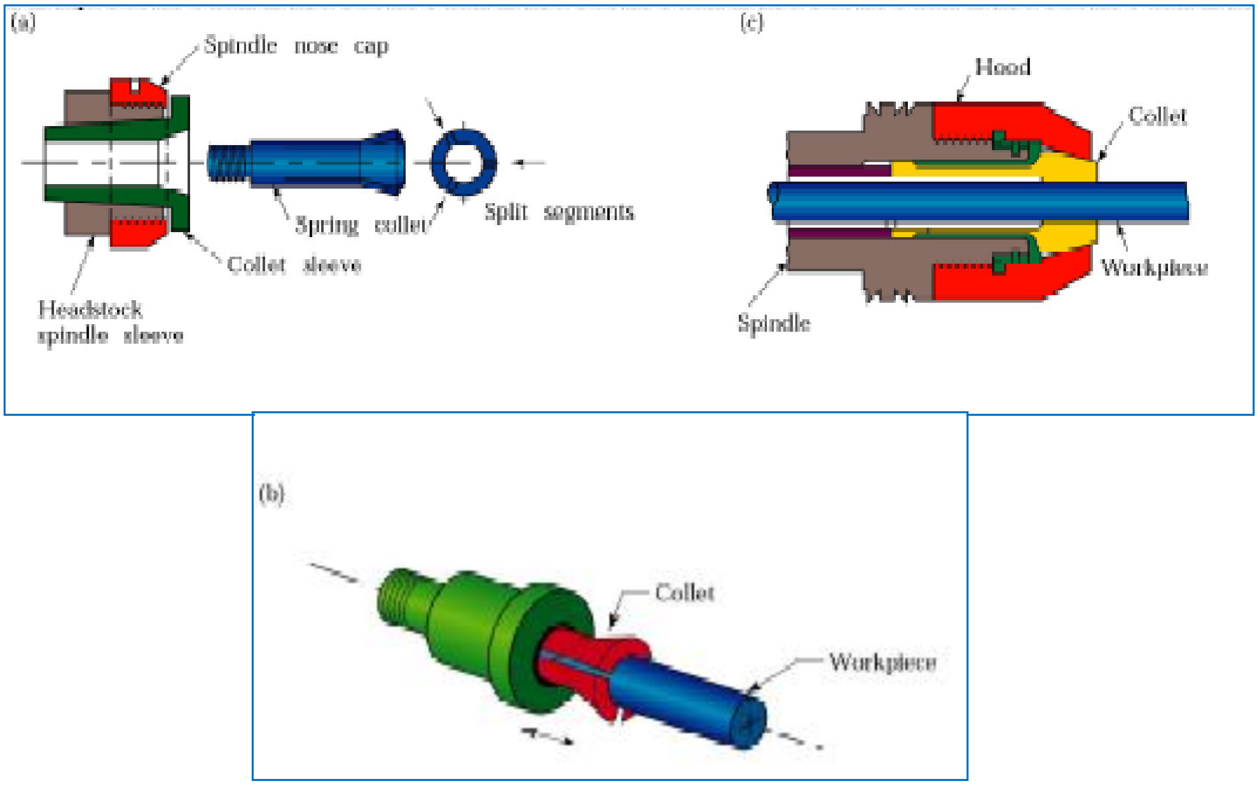
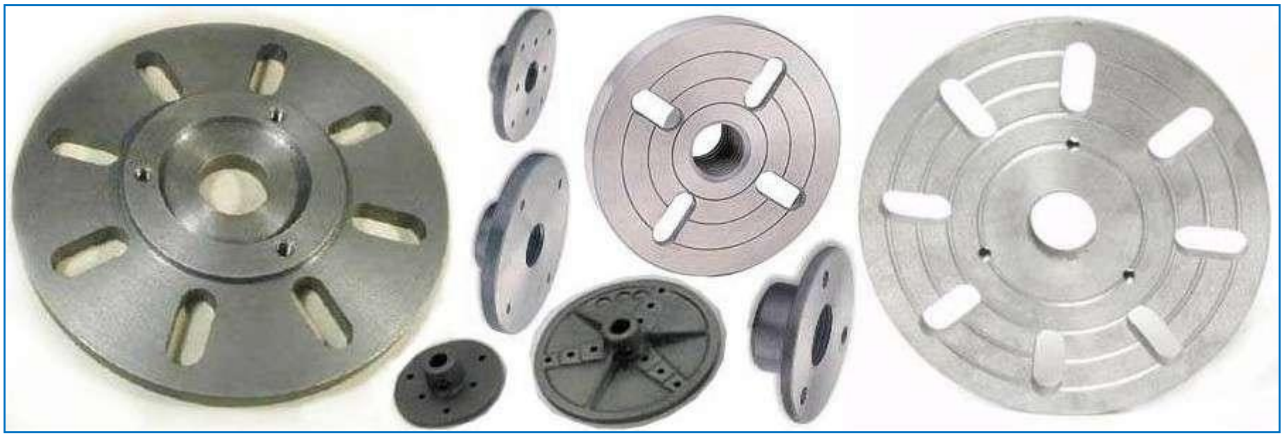


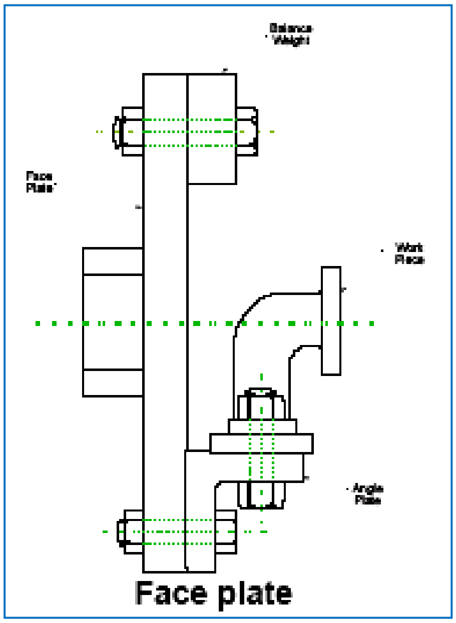
Fig: (a) and (b) Schematic illustrations of draw-in-type collets. The workpiece is placed in the collet hole, and the conical surfaces of the collet are forced inward by pulling it with a draw bar into the sleeve. (c) A push-out type collet.

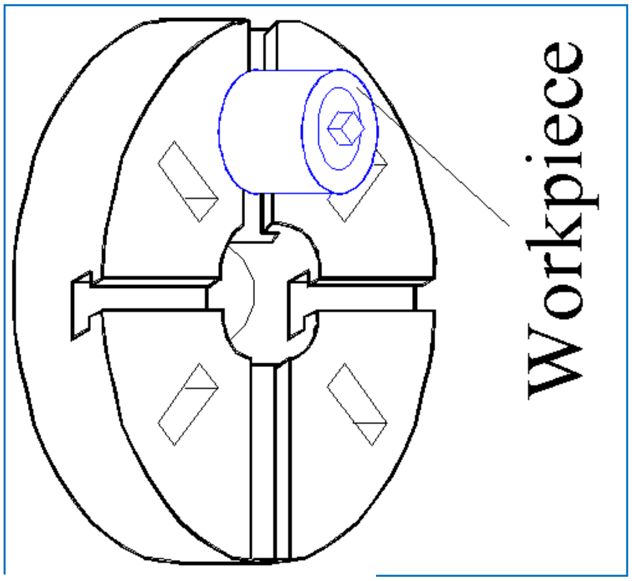
2-Faceplates:

- A faceplate consists of a circular disc bored out and thread to fit the nose of the spindle. This has radial, plain and T slots for holding work by bolts and clamps.
- Faceplates are used for holding irregularly shaped workpieces, which cannot be held conveniently held between centers or chucks.
- When eccentric jobs are bolted on the faceplate, a balance weight or counter weight must be added.



Various shapes of faceplates





3-Angle plates:

- This is a cast iron plate having two faces machined to make them absolutely at right angles to each other.
- Holes and slots are provided on both faces so that it may be clamped on the faceplate and can hold the workpiece on the other face by clamps and bolts.
- Angle plates are used in conjunction with a faceplate when the holding surface of the workpiece should be kept horizontal, as for example, in machining a flange of a pipe elbow.

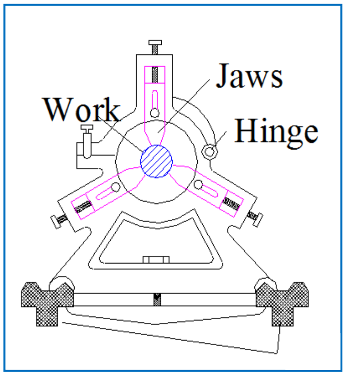
4-Rests:

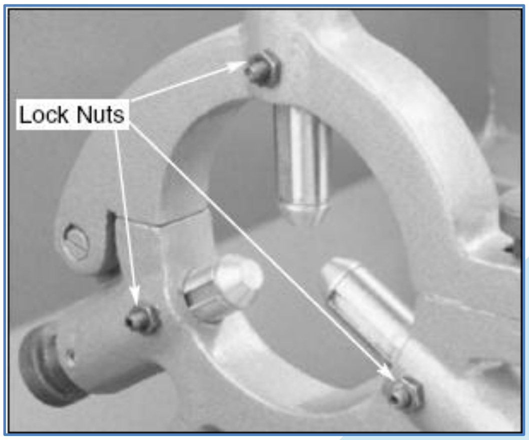
- When very long job is to be turned between centers on lather, due to its own weight itprovides a springing action and carries a lot of bending moment. The result is that turning tool is damaged very soon, and may even break sometimes. To avoid this, such jobs are always supported on an attachment known as "rest" .This prevent the deflection of the job.

Types:

1. Steady rest:

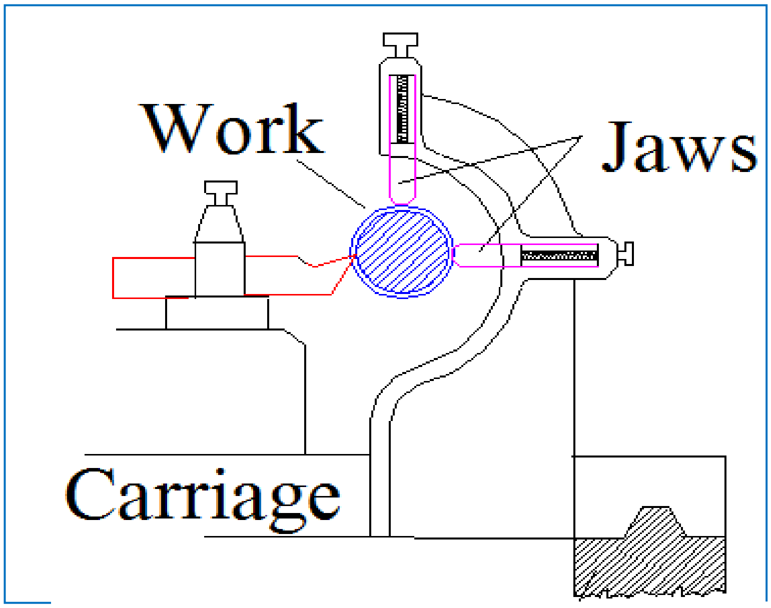
- A steady rest consists of cast iron base, which may be made to slide on the lathe bed ways and clamped at any desired position where support is necessary. This is designed so that the upper position is hinged at one end, which facilitates setting and removal of the workpiece without disturbing the position of the steady rest.
- There are three jaws on the steady rest, two on the lower base and one on the upper frame, the jaws may be adjusted radially by rotating individual screws to accommodate work of different diameters.
- For a very long work, more than one steady rest may be used. However, the carriage cannot be fed to the full length of the work when steady rest is used.The steady rest supports long, small diameter stock that otherwise could not be turned. The steady rest can also replace the tailstock to allow for cutting tool access at the outboard end of the workpiece.

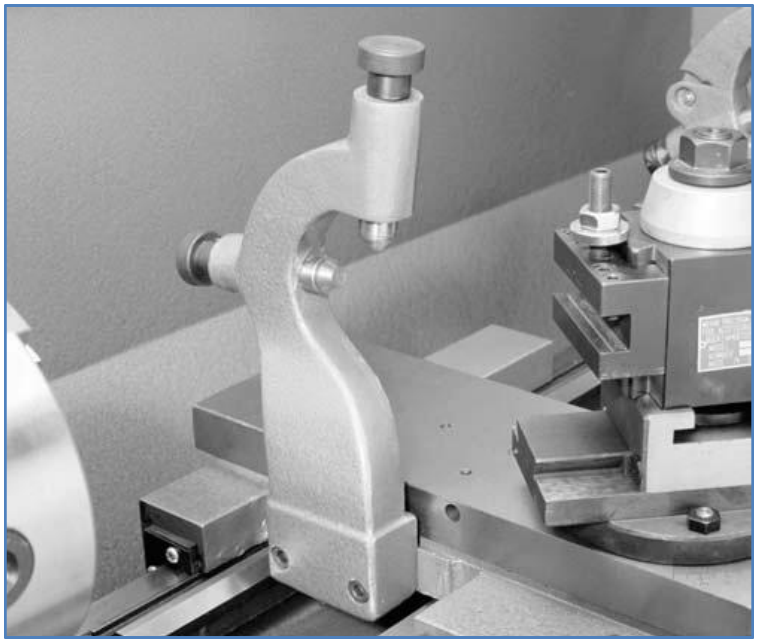




2. Follower rest:

- A follower rest consists of a "C" like casting having two adjustable jaws, which support the work.The rest is bolted to the back end of the carriage and moves with it.
- Before setting the follower rest, the end of the workpiece is machined slightly wider than the jaws to provide the true bearing surface.
- The tool is slightly in advance position than the jaws, and the tool is fed longitudinally with the carriage, the jaws always follow the tool giving continuous support to the workpiece. The follower rest prevents the job from springing away when the cut is made and is used in finish turning operation.





VII- Similarities and differences

The common between the capstan and turret

- It is a semi-automatic lathe.
- Tool changing time is small with respect to the conventional lathes.
- It is suitable for mass production.
- Tool can be changed without stopping the machine.
- Front and rear tool posts are available.
- Tool changing time is small.
- It has turret head instead of tailstock.
- The tools are controlled by feed stops.
- The tool is centered automatically.
- Six different tools can be fitted in the turret head.
- More than one operation can be done at a time
- High number of speeds.

Differences between capstan and turret lathes:

	Capstan lathe	**Turret lathe**
Construction	The turret is mounted on a *ram* (auxiliary slide) which moves on the guide ways of the saddle which moves on the bed of the capstan lathe.	The turret is directly mounted on the saddle, which moves on the bed of the turret lathe.
Travel length	Travel of the turret is dependent upon the length of the travel of the ram. This limits the maximum length of work to be machined in one setting.	Turret saddle moves on total length of bed, this enables the turret to be moved in entire length of the bed and can machine longer workpieces.
Feeding	• The saddle is at a convenient distance from the work and the tools are fed by moving the ram (slide) • Hand feeding is easy as the hexagonal turret can be moved forward and backward more rapidly without moving saddle unit. • The turret head cannot be moved crosswise.	• The saddle is moved to feed the tools to the work. • Hand feeding is a difficult process due to the movement of the entire saddle unit. • The turret head can be moved crosswise in some turret lathes.

Rigidity	*It is a light duty machine*. The tool support unit is subjected to bending and deflection due to the existence of more moving parts [Ram, Saddle & turret] leading to extra vibrations It is not capable of withstanding heavy cutting loads and severe cutting conditions.	*It's heavy duty machine.* The arrangement enables a very high rigidity because all the cutting forces are transferred to the lathe bed. It is capable of handling heavier jobs involving high cutting forces and severe cutting condition.
Operator's fatigue	It offers low fatigue to the hands of the operator due to low weight of turret.	It offers high fatigue to the hands of the operator due to high weight of turret.
Holding workpieces	Collet is mainly used to hold the workpiece due to the small workpieces size.	Jaw chuck is mainly used to hold the workpiece due to the large workpieces size.

Differences between conventional and semi-automatic lathes:

	Centre lathe	Capstan/turret lathe
1	It is mostly manual lathe	It is mostly semi-automatic lathe
2	It has tail stock	It has turret head instead of tail stock
3	It has only one tool post only	Front, rear tool posts and turret are available
4	Only one tool can be fitted in the tailstock, so only one operation is done at a time.	Six different tools can be fitted in the turret head , so more than one operation can be done with less time of tool changing
5	It is not suitable for patch production	It is suitable for patch production
7	Speed range is less	Speed range is high
8	No feed stops to control the tool	The tools are controlled by feed stops
9	The tool is centered manually after changing the tool	The tool is centered automatically

Specification

The size of a lathe is specified by two or three dimensions:

- Maximum swing diameter without touching the bed (C): The largest diameter workpiece, which will clear the bed of the lathe. The center is the headstock spindle center.
- Maximum swing diameter without touching the cross slide (D): The largest diameter workpiece, which will clear the cross, slide is sometimes also specified.
- Distance Between spindle and turret (B): The longest workpiece, which can be held on centers between the headstock and the tailstock.
- Length of Bed (A).
- The range of speeds and feeds, and the horsepower available.

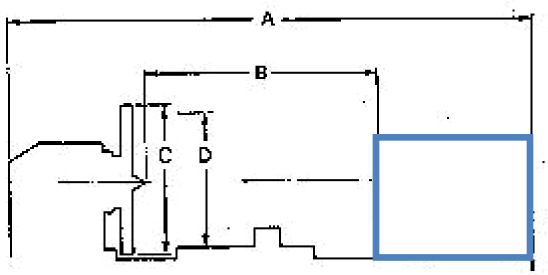


Fig. 10-3. Study how the lathe is measured. A-Length of bed. B-Distance between centers. C-Diameter of work that can be turned over two ways. D-Diameter of work that can be turned over cross slide.

	Specifications of different models of Capstan lathe			
	MODEL	**ABL-25**	**ABL-32**	**ABL-40**
●	Maximum Bar Turning Cap. (mm)	25	32	40
●	Height of Centre (mm)	165	165	190
●	Swing over bed (mm)	300	300	400
●	Swing over cross slide (mm)	165	165	200
●	Chucking Diameter of Chuck (mm)	165	165	200
●	Max. distance between Spindle Face and Turret Head (mm)	275	500	560
●	Number of Spindle Speeds	3	6	12
●	Range of Spindle Speeds (RPM)	650 - 1660	162 - 1500	98 - 1040
●	Max. useful stroke of Capstan Slide (mm)	95	95	200
●	Cross Slide Movements (mm)	110	200	250
●	Diameter of Holes in Turret (mm)	25.4	25.4	32
●	Length x Width of Bed (mm)	900 x 165	1200 x 180	1400 x 230

•	Approximate Net / Gross weight (kg.)	750 / 900	1200 / 1500	1800 / 2200
•	Approximate Shipping Dimensions (mm)	1350x765x1400	1650x900x1450	1800x1100x1500
•	Approximate Shipping Volume (m^3)	1.45	2.20	3.00

Specification of different models of Turret lathes

Specification	**TC25**	**TC32**
CHUCKING CAPACITY		
Type of Chucking	Collet	Collet
Maximum bar size in Collet Round	Ø 25 mm	Ø 32 mm
Maximum bar size in Collet Hexagonal	A/F22 mm	A/F27 mm
Maximum bar size in Collet Square	A/F18 mm	A/F22 mm
SPINDLE DRIVE		
Type of drive	'V' Belt	'V' Belt
Number of speeds	16	16
Speed Range	125-3100rpm	125-3100rpm
SLIDES		
Cross Slide Traverse	50 mm	50 mm
Long Turning Traverse	25 mm	25 mm
Vertical Slide Traverse	90 mm	90 mm

POWER		
Main Motor (3 Phase, 415V, 50 Hz)	0.5/2 HP	0.5/2 HP
Motor Speed	720/2800rpm	720/2800rpm
OPTIONAL ATTACHMENTS & ACCESSORIES		
Automatic gravity bar feed (3mts length)	Back Stopper	
Auto Threading Attachment	Back plate for 4" chuck	
SB 10 Collet Holder	Turning tool holder (Single)	
A 3 Collet Holder	Turning tool holder(Double)	

VIII- References:

1- **Manufacturing Technology – II, Dr. R.Kesavan,B. Vijaya Ramanath**

2- **www.crcnetbase.com(http://www.crcnetbase.com/doi/abs/10.1201/9781420043402.ch6)**

3- **www.ustudy.in(http://www.ustudy.in/node/7743)**

4- **www.finexindustries.co.in(http://www.finexindustries.co.in/capstan-lathe.htm)**

5- **Others**